Aeronautics Committee Report to the NASA Advisory Council

Ms. Marion Blakey (Chair)

April 24, 2013

Committee Information

- **Members:**
  - Ms. Marion Blakey, Chair (Aerospace Industries Association)
  - Mr. John Borghese (Rockwell Collins)
  - Dr. Ilan Kroo (Stanford University)
  - Dr. John Langford (Aurora Flight Sciences)
  - Mr. Mark Anderson (Boeing)
  - Dr. John-Paul Clarke (Georgia Institute of Technology)
  - Mr. Mark Pearson (General Electric)*
  - Dr. Mike Francis (UTRC)
  - Dr. Mike Bragg (University of Illinois)
  - Mr. Tommie Wood (Bell Helicopter)
- Plans for next meeting: Face-to-face Committee Meeting at NASA Headquarters, July, 2013.

*Attended remotely

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CY 2012 Work Plan

1) Review ARMD revised rotorcraft portfolio including the relevance to industry. Provide feedback on ARMD rotorcraft vision, research content, and planning process.

2) Review deliberations and initial activities of the Unmanned Aircraft Systems Subcommittee (UASS). The Committee will assess their yearly work plan and advise on areas of improvement.

3) Provide advice and innovative suggestions for conducting flight research within the current Aeronautics portfolio. The Committee will provide guidance concerning strategies for partnerships and lower cost flight research that has proved beneficial based on their industry and academic experience.

4) Provide guidance to the Integrated Systems Research Program to inform future program planning and enable a high degree of contribution and relevance to national aeronautics objectives. The Committee will provide suggested topics of future projects by ISRP in line with Program goals and Directorate Strategic Implementation Plan.

5) Review study plans, results and progress of the National Research Council-led Autonomy study. The Committee will provide an independent assessment of planning efforts in regards to the study outcomes and, if applicable, recommend follow on ARMD activities

Areas of Interest Explored at Current Meeting

Topics covered at the Aeronautics Committee meeting held on February 28 - March 1, 2013 at NASA Headquarters:

Budget Status

ARMD Strategic Planning*

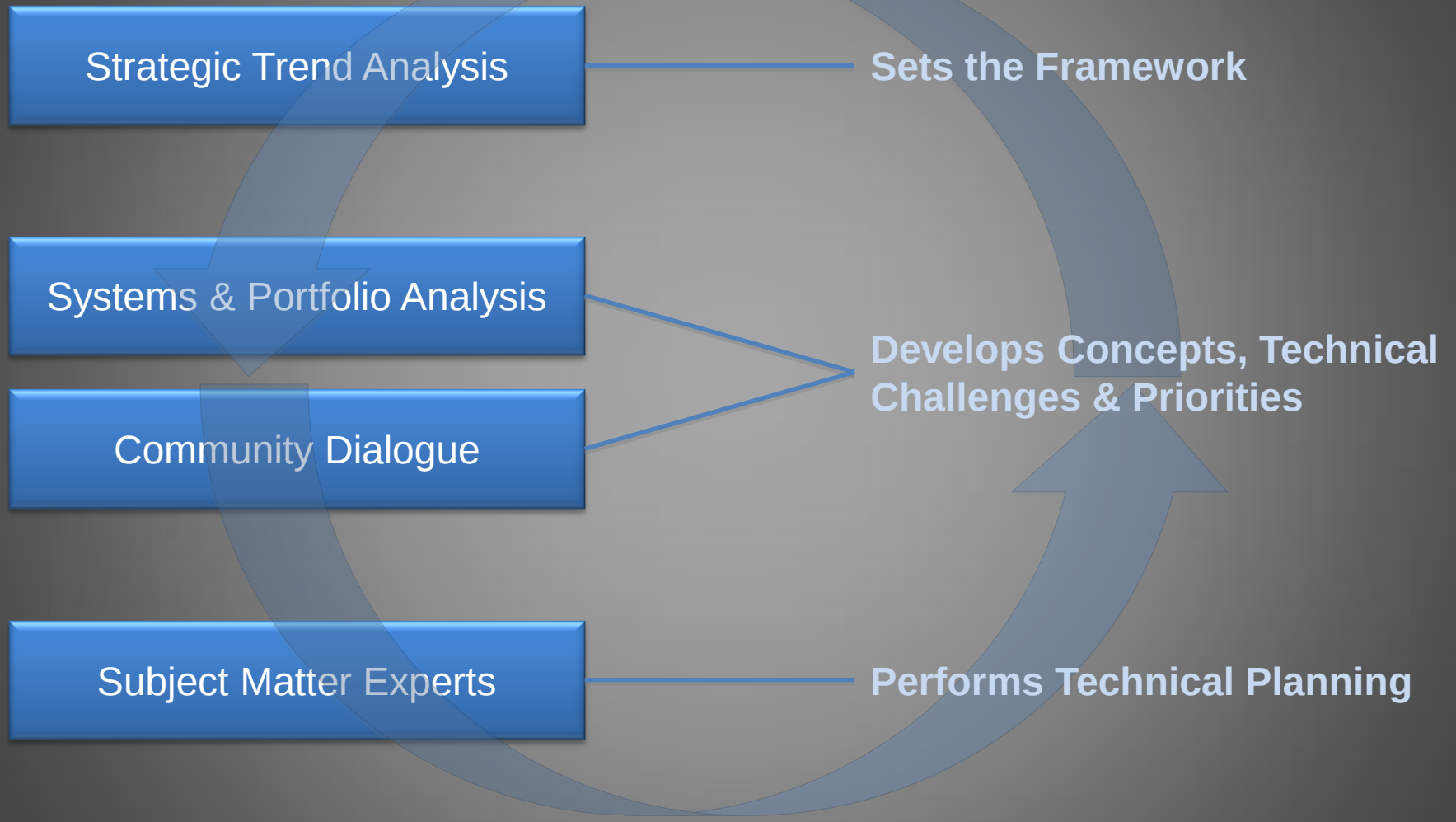
ISRP Future Direction

NRC Autonomy Study Planning

UAS Subcommittee Outbrief*

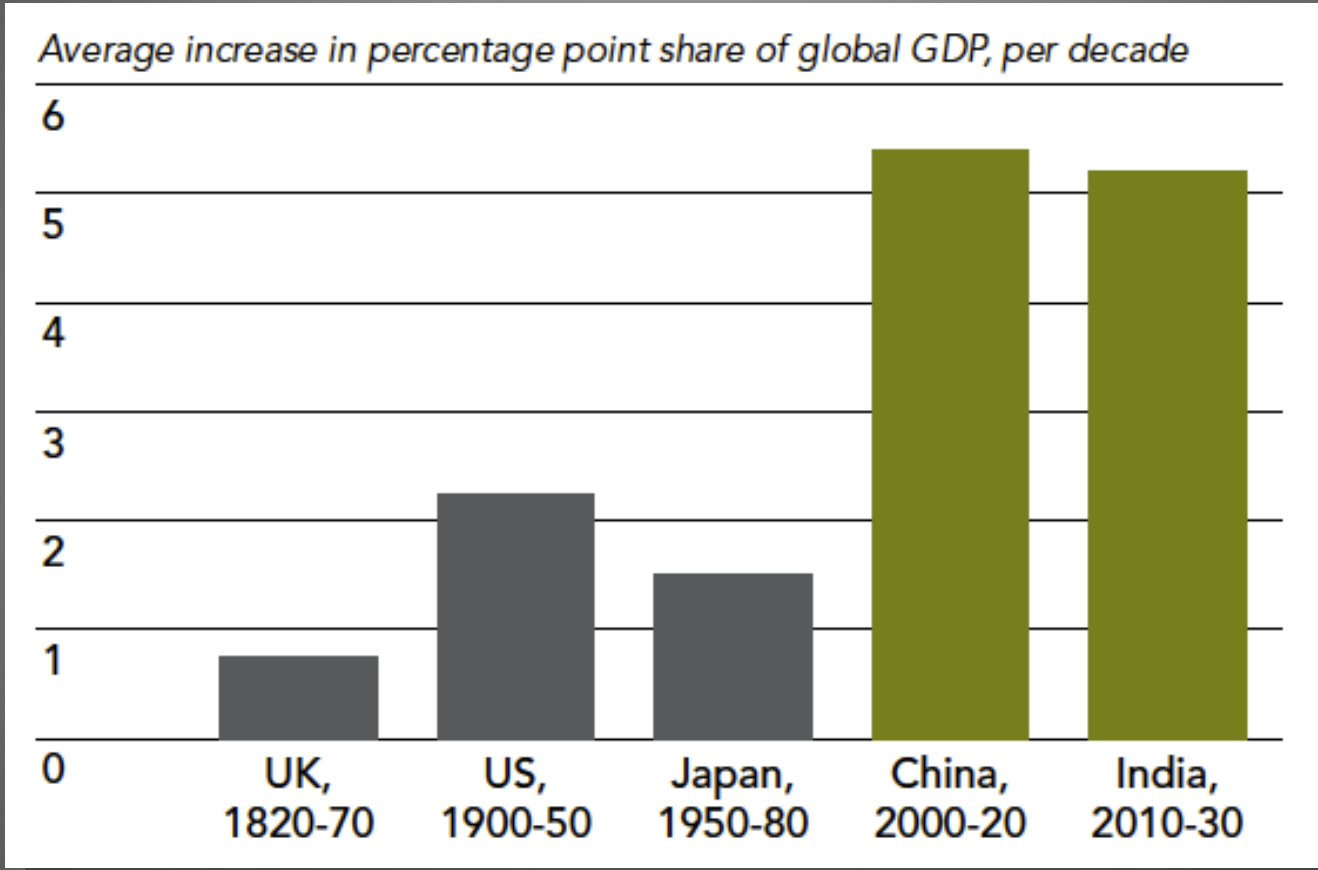
* This topic has a related finding or recommendation provided by the Aeronautics Committee

ARMD Approach to Planning



Strategic Trend Analysis

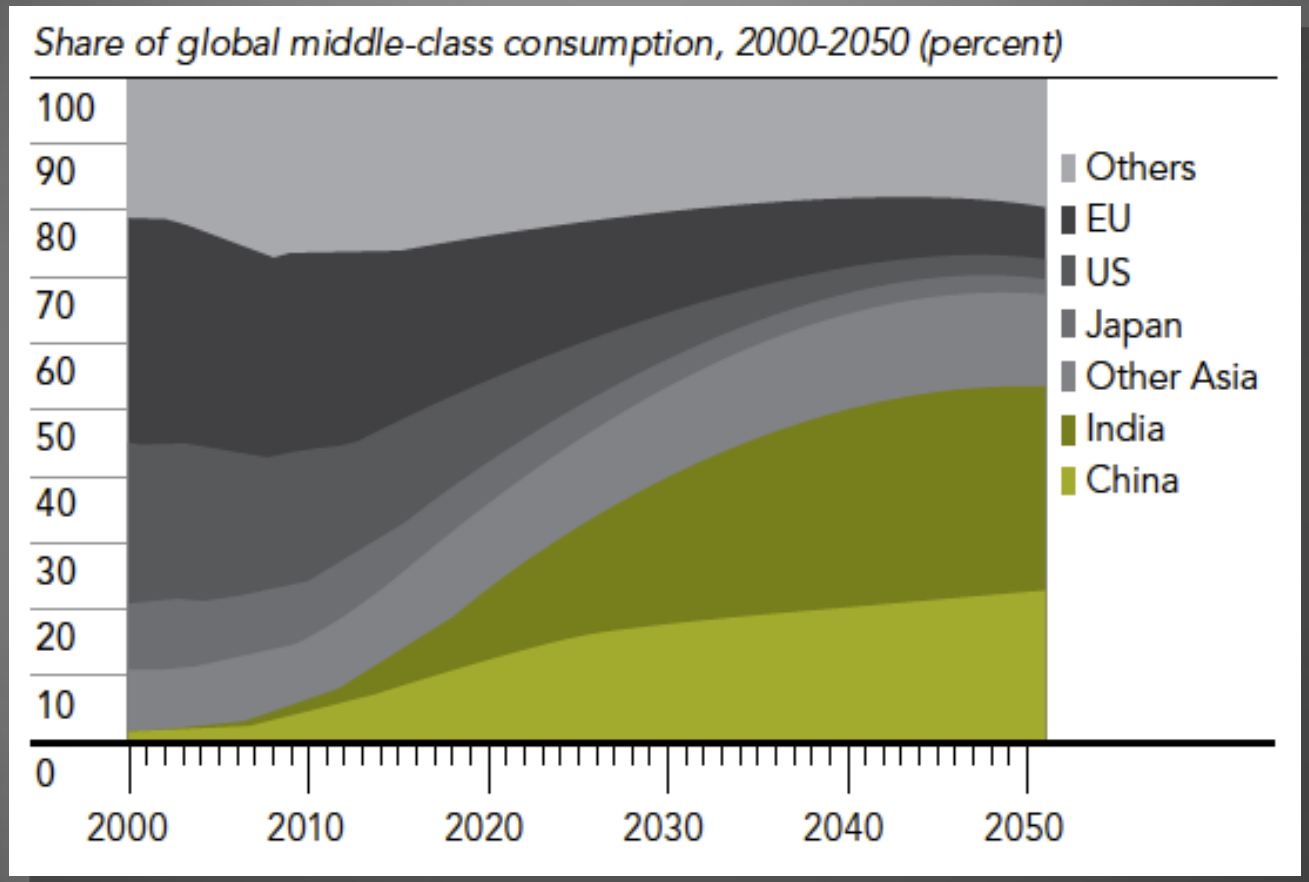
China & India Growing Economically at Historically Unprecedented Rates



Source: National Intelligence Council

Strategic Trend Analysis (cont.)

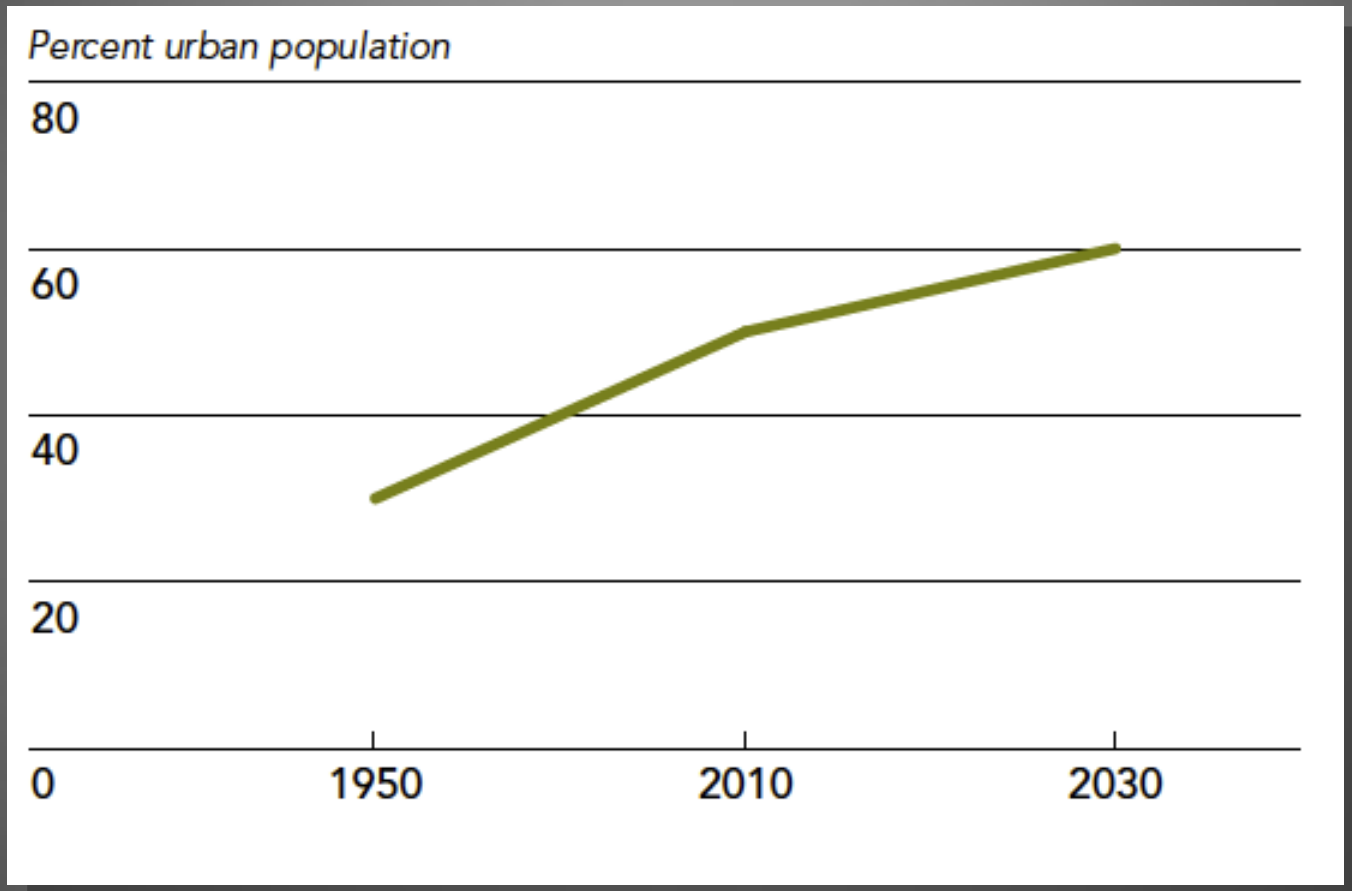
Asia-Pacific region will have the Largest Middle-Class



Source: National Intelligence Council

Strategic Trend Analysis (cont.)

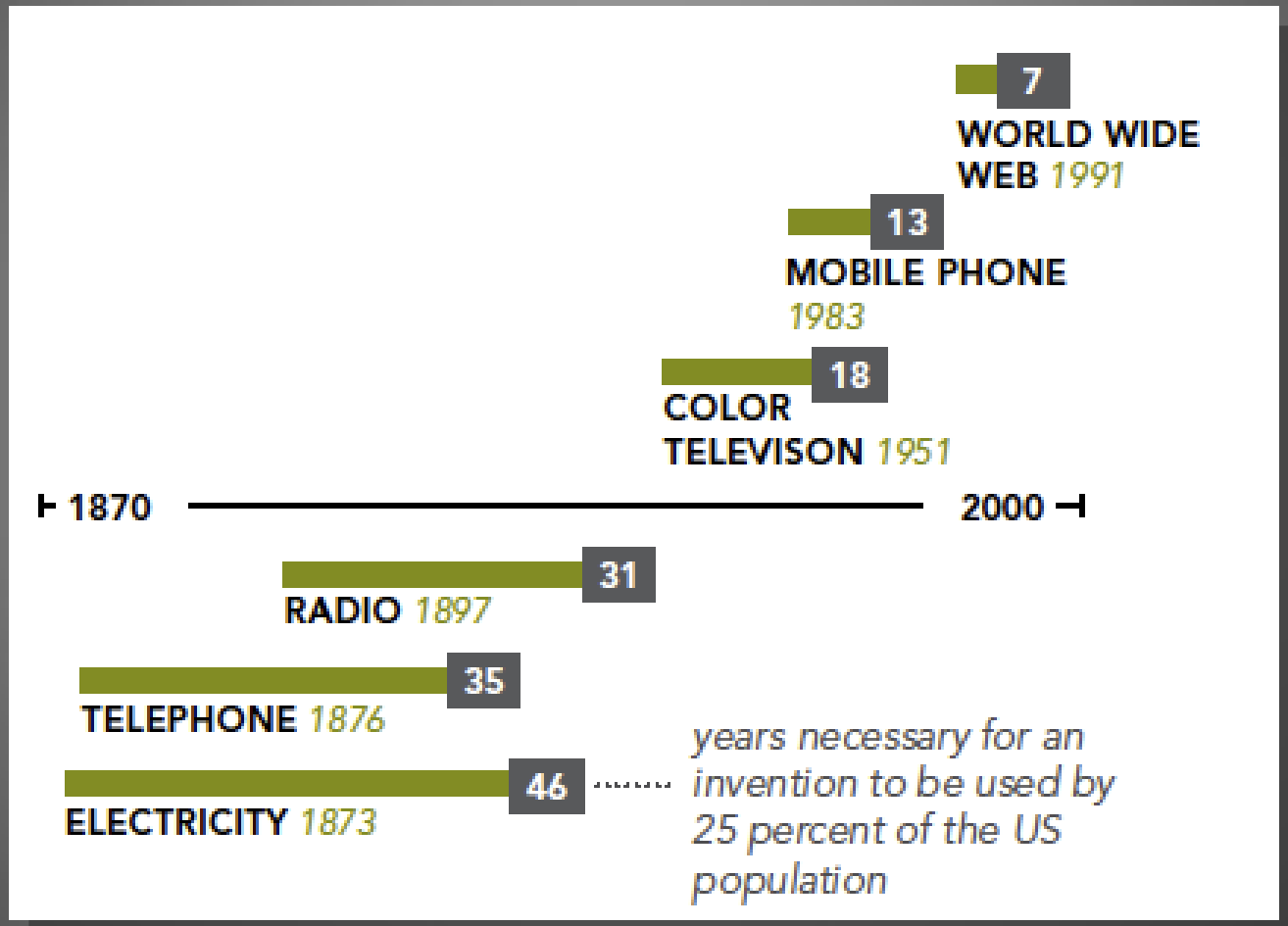
The World will be Predominantly Urban



Source: National Intelligence Council

Strategic Trend Analysis (cont.)

Technology Development & Adoption is Accelerating



Source: National Intelligence Council

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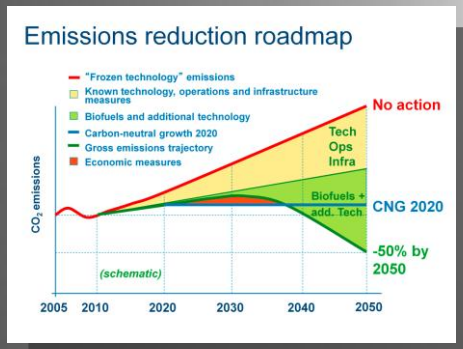
Mega-Drivers
Aviation Research & Technology

Traditional measures of global demand for mobility growing rapidly
- Rapid growth of developing economies
- Global urbanization



Critical energy and climate issues create enormous affordability and sustainability challenges

Revolution in automation, information and communication technologies enable opportunity for safety critical autonomous systems

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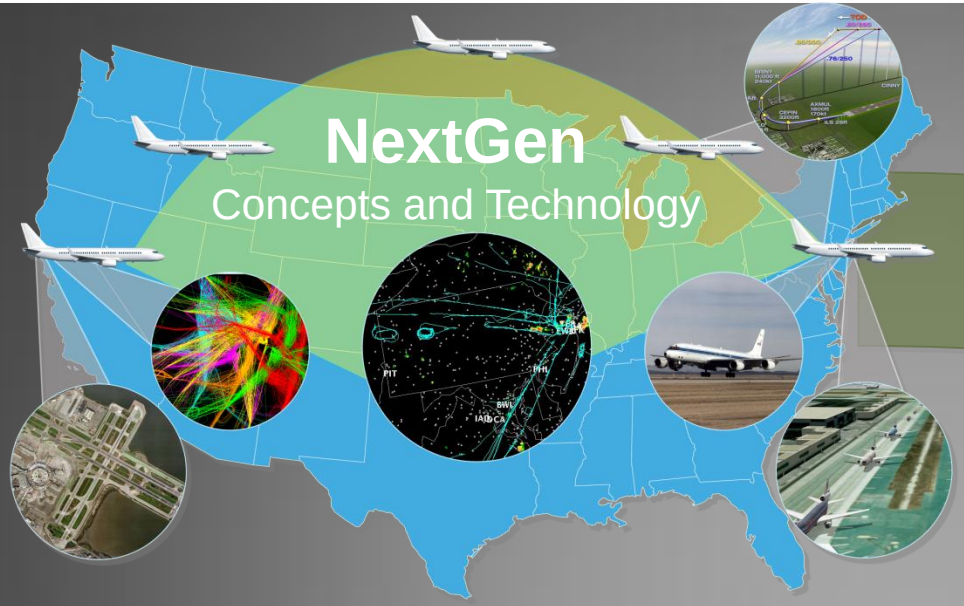
Systems & Portfolio Analysis



N+2
Concepts and Technology



N+3
Concepts and Technology



Core Technologies support needed capacity growth and enable simultaneous reduction in energy use, noise and emissions

- Structural, Aerodynamic & Propulsion Component Efficiency
- New Configurations
- Automation for Efficient TBO Operations

However, performance gaps remain to fully account for future challenges in mobility, cost and climate

Low Carbon Fuels and Propulsion closes gaps in carbon emissions

Autonomy closes gaps in cost and enables mobility innovation

Community Dialogue

Advance ongoing research in NextGen, Safety, Green Aviation, and UAS Access

Undertake or Expand upon Transformational Enablers
- Autonomy
- Composite Structures
- More Electric Aircraft

Aeronautics R&T Roundtable

Need Tools for More Rapid Innovation
- Virtual Testing
- V&V of Complex Systems

Demonstrate Low-Boom Supersonic Flight

Flight Research is a Critical Element of Technology Maturation and Public-Private Partnership

ARMD Strategic Implementation Plan

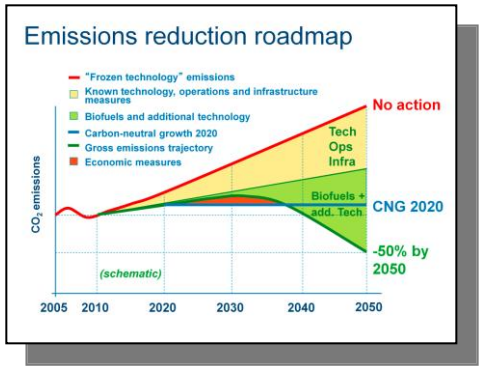
- Describes ARMD's strategic management approach.
- Represents how ARMD aligns NASA's aeronautics investments to achieve national goals.
- Articulates ARMD's goals and strategies to provide guidance for program and project planning and execution.
- Establishes a context for measuring progress.
- Formalizes the use of Technical Challenges for strategic management of ARMD research.

Technical Challenge Example

Target : Eliminate turbofan engine interruptions, failures, and damage due to flight in high ice-crystal content clouds	
Technical Challenge Title & Description	**Products/Deliverables**
Title = Engine Icing Characterization and Simulation Description = Develop knowledge bases, analysis methods, and simulation tools needed to address the problem of engine icing, in particular, ice-crystal icing	• Ice-crystal icing environment characterization (FY15) • Validate engine ice-crystal icing test methods and techniques (FY15) • Validate and verify icing codes to determine potential engine core ice accretion sites and accretion rates (FY25) • Validate and verify engine simulation codes to predict ice-degraded engine and engine component performance (FY25)

Strategic Response

3 Mega-Drivers



6 Strategic Research & Technology Thrusts

Safe, Efficient Growth in Global Operations
- Enable full NextGen and develop technologies to substantially reduce aircraft safety risks

Innovation in Commercial Supersonic Aircraft
- Achieve a low-boom standard

Ultra-Efficient Commercial Transports
- Pioneer technologies for big leaps in efficiency and environmental performance

Transition to Low-Carbon Propulsion
- Characterize drop-in alternative fuels and pioneer low-carbon propulsion technology

Real-Time System-Wide Safety Assurance
- Develop an integrated prototype of a real-time safety monitoring and assurance system

Assured Autonomy for Aviation Transformation
- Develop high impact aviation autonomy applications

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Committee Finding

The Committee endorses the approach that NASA ARMD is taking to establish a strategic direction to inform future research portfolio decisions. The Committee feels that the underlying process of utilizing strategic trends analysis, systems and portfolio analysis, and community/stakeholder engagement will enable ARMD to respond more effectively to new needs and new approaches to plan future research. The Committee notes that ARMD has made significant progress in an area which the Committee had commented on in a previous observation (regarding the use of systems analyses and trade studies to inform prioritization and advocacy of ARMD research - August 2011). The Committee looks forward to engaging with ARMD as their efforts mature and helping to inform the plan.

ISRP Portfolio

Integrated Systems Research Program (ISRP) Goal

Pursue innovative solutions to high priority aeronautical needs and accelerate implementation by the aviation community through integrated system level research on promising concepts and technologies, demonstrated in a relevant environment

- ISRP Projects have a finite resources and a finite life with defined project termination date
  - Environmentally Responsible Aviation Project will be completed at the end of FY2015
  - Unmanned Aircaft Systems Integration into the National Airspace System Project will be finished at the end of FY2016

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Potential ISRP Future Projects

Potential ISRP Future Projects

- Low-Boom Flight Demonstrator & Possible Other Testbeds
- Advanced Composites
- Autonomy Research

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Autonomy Research

- *" Future aviation vehicles and systems (both manned and unmanned) will be more highly automated, and will require the implementation of software systems of varying degrees of complexity coupled with advanced hardware and communications capabilities. Thus, there is a need for research and development that will lead to an overall aviation system that can be operated safely with vehicle and systems of varying levels of autonomy. Autonomy has the potential to reduce costs, increase performance, productivity, safety, and efficiency and enable new operational models for aviation." NASA Advisory Council Recommendation : Autonomy Research in Aviation*
- An internal planning team will be developed to lay out the issues and potential NASA approaches to address the following areas:
  - Key technical barriers
  - Design issues with the human-machine interface
  - Approaches to test, evaluation and certification
  - NAS integration
- The National Academy of Sciences will perform a detailed study for ARMD of the research requirements to achieve autonomous systems from a National perspective, to ensure NASA has the best insight into what is occurring throughout the aerospace and other industries today and what the full set of research challenges are.

NRC Proposal – overview/background

- Aeronautics and Space Engineering Board (ASEB) proposes to establish an ad-hoc study committee to develop a national agenda for autonomy in civil aviation, comprised of a prioritized set of integrated and comprehensive technical goals and objectives of importance to the civil aeronautics community and the nation.

- Study plan developed with input from NASA, FAA, and USAF

- Reference existing national/federal guidance on federal investments in R&D related to autonomy:
  - National Aeronautics R&D plan
  - JPDO Integrated Work Plan for NextGen
  - DOD (Defense Science Board, other documents)
  - NRC Decadal Survey of Civil Aeronautics

- Intent is to understand existing state of the art and ongoing R&D in autonomy for aerospace and other applications.

- Possible NAC/NRC committee interaction during data collection phases (Second and/or Third meeting)?

UAS Subcommittee Roadmap

- Meeting 1 (Dec 2011): Overview of the NASA UAS in the NAS Project
- Meeting 2 (June 2012): More detailed look at the project
- Meeting 3 (Oct 2012): FAA Context
  - Rick Prosek, FAA UAS
  - Sabrina Saunders-Hodge, FAA ANG-C2
  - Maureen Keegan, Joint Program and Development Office (JPDO)
  - Dr. Wanke, MITRE
- Meeting 4 (February 2013): FAA Aviation Rulemaking Committee (ARC) & JPDO Coordination
  - Ed Waggoner – UAS ARC & NASA Integration
  - Debra Randall – Systems Engineering update
  - Yuri Gawdiak, NASA Assignee to JPDO, Future Aircraft Integration with NEXTGEN
- Meeting 5 (May 2013)
- Meeting 6 (July 2013)

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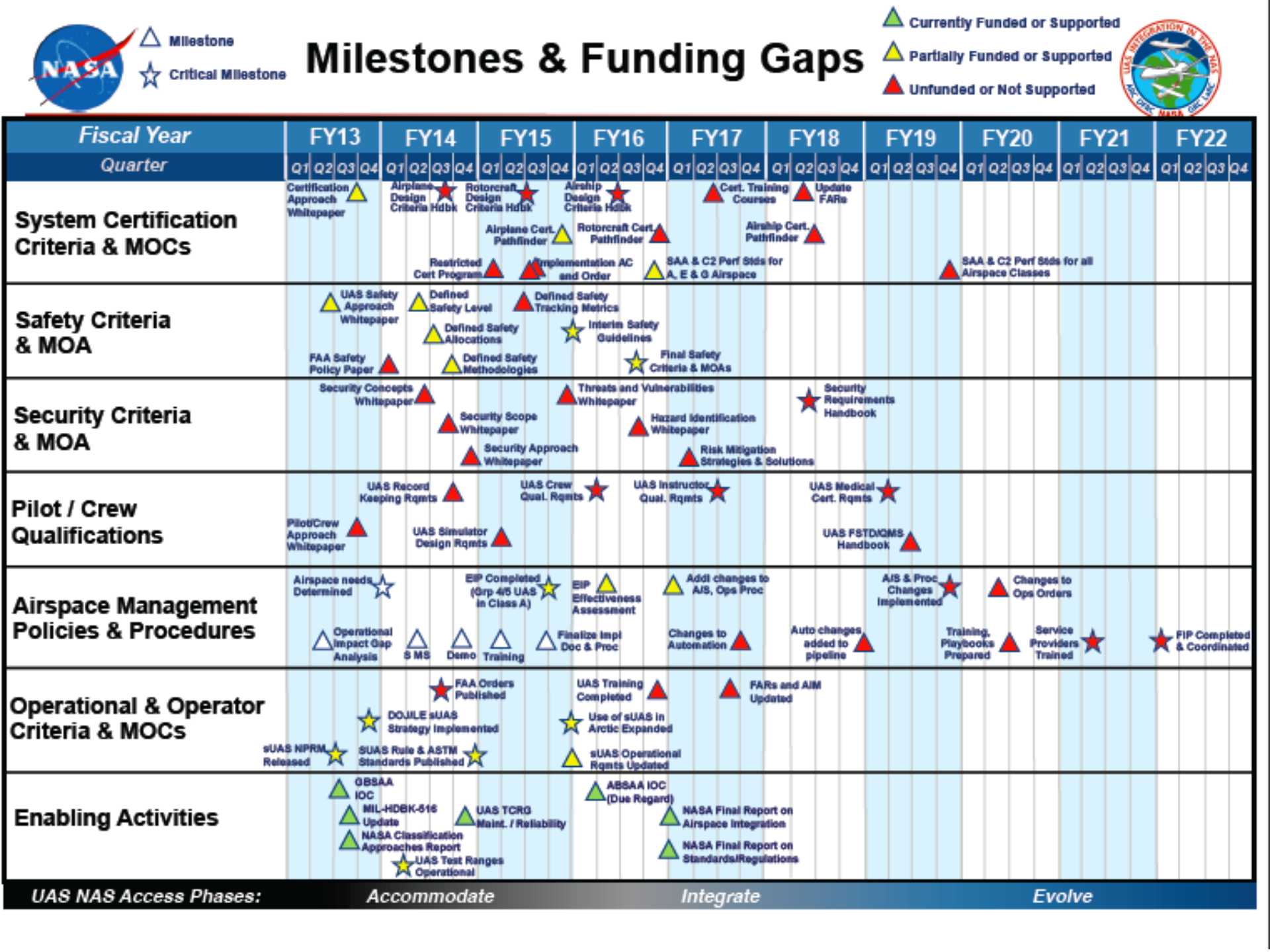
UAS Subcommittee Members

• Dr. John Langford (Chair)	Aurora Flight Sciences
• Ms. Rose Mooney	Archangel Aero LLC
• Dr. Brian Argrow	University of Colorado
• Dr. Eric Johnson	Georgia Institute of Technology
• Mr. Nick Sabatini	Nick Sabatini & Associates
• Dr. Steve Sliwa (2011-2012)	Morning Wings LLC
• Dr. Dave Vos	(formerly Rockwell Collins)
• Ms. Lynn Ray	FAA
• COL Dean Bushey	US Air Force

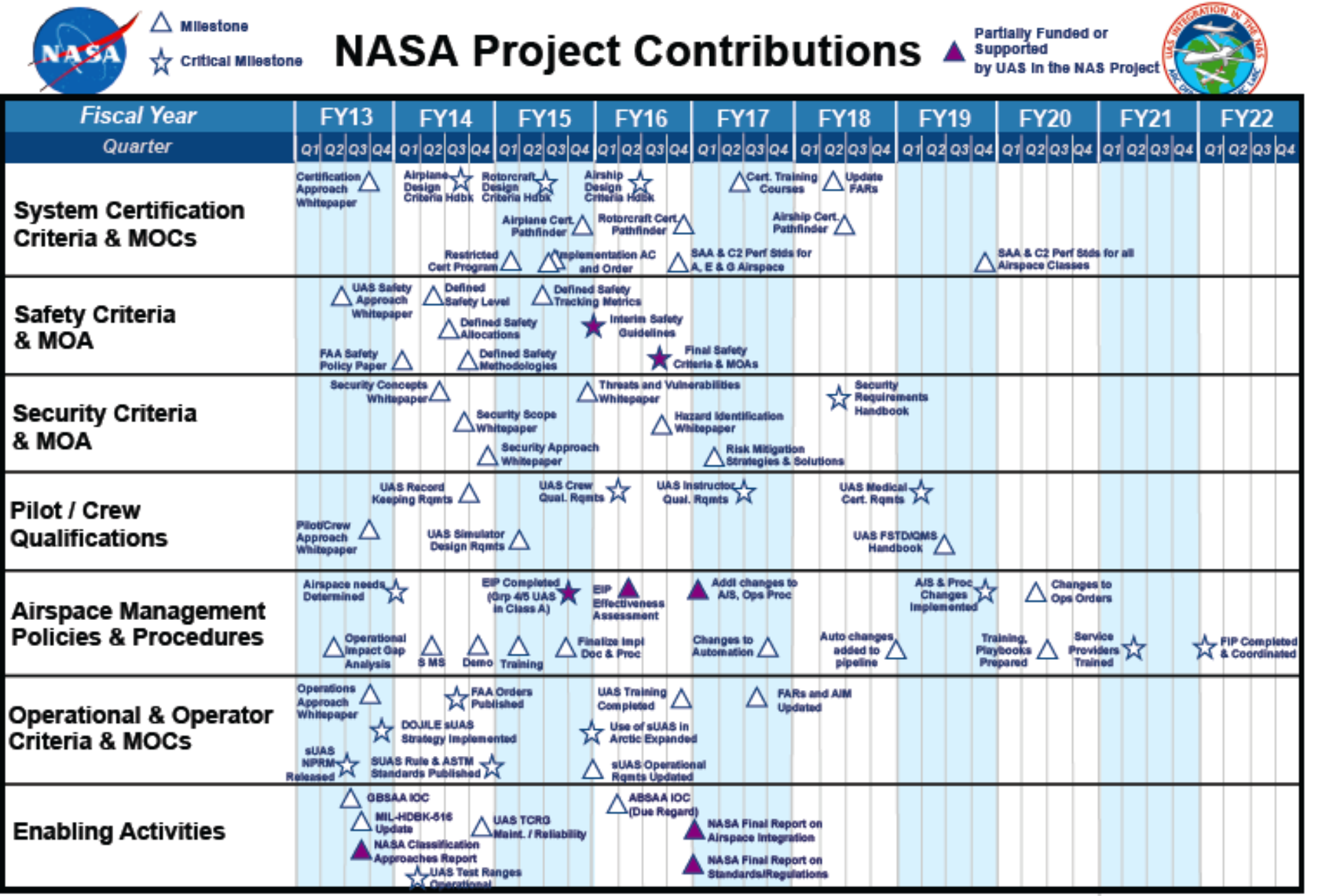
Major Discussion Topics, February

- Relationship between NASA Project and the FAA UAS Aviation Rulemaking Committee (ARC) work
  - Project is tightly aligned with the work of the UAS ARC and its timelines
  - Project personal assisting with specific working groups, particularly the Implementation Planning Working Group (IPWG)
- Role of Systems Engineering in designing & informing Project Task Elements
- UAS Systems Analysis Work
  - NASA sponsored analysis performed by the Joint Planning and Development Office (JPDO) Interagency Portfolio and Systems Analysis (IPSA) Division
  - Flight projections and business case preliminary results show that the impact of UAS will be significant.


Milestone
Critical Milestone
Milestones & Funding Gaps
Currently Funded or Supported
Partially Funded or Supported
Unfunded or Not Supported
Fiscal Year
Quarter
FY13
FY14
FY15
FY16
FY17
FY18
FY19
FY20
FY21
FY22
Q1 Q2 Q3 Q4
System Certification Criteria & MOCs
Certification Approach Whitepaper
Airplane Design Criteria Hdbk
Rotorcraft Design Criteria Hdbk
Airship Design Criteria Hdbk
Cert. Training Courses
Update FARs
Airplane Cert. Pathfinder
Rotorcraft Cert. Pathfinder
Airship Cert. Pathfinder
Restricted Cert Program
Implementation AC and Order
SAA & C2 Perf Stds for A, E & G Airspace
SAA & C2 Perf Stds for all Airspace Classes
Safety Criteria & MOA
UAS Safety Approach Whitepaper
Defined Safety Level
Defined Safety Tracking Metrics
Defined Safety Allocations
Interim Safety Guidelines
FAA Safety Policy Paper
Defined Safety Methodologies
Final Safety Criteria & MOAs
Security Criteria & MOA
Security Concepts Whitepaper
Threats and Vulnerabilities Whitepaper
Security Requirements Handbook
Security Scope Whitepaper
Hazard Identification Whitepaper
Security Approach Whitepaper
Risk Mitigation Strategies & Solutions
Pilot / Crew Qualifications
UAS Record Keeping Rqmts
UAS Crew Qual. Rqmts
UAS Instructor Qual. Rqmts
UAS Medical Cert. Rqmts
Pilot/Crew Approach Whitepaper
UAS Simulator Design Rqmts
UAS FSTD/QMS Handbook
Airspace Management Policies & Procedures
Airspace needs Determined
EIP Completed (Grp 4/5 UAS in Class A)
EIP Effectiveness Assessment
Addl changes to AIS, Ops Proc
AIS & Proc Changes Implemented
Changes to Ops Orders
Operational Impact Gap Analysis
SMS
Demo
Training
Finalize Impl Doc & Proc
Changes to Automation
Auto changes added to pipeline
Training, Playbooks Prepared
Service Providers Trained
FIP Completed & Coordinated
Operational & Operator Criteria & MOCs
FAA Orders Published
UAS Training Completed
FARs and AIM Updated
DOJ/LE sUAS Strategy Implemented
Use of sUAS in Arctic Expanded
sUAS NPRM Released
SUAS Rule & ASTM Standards Published
sUAS Operational Rqmts Updated
Enabling Activities
GBSAA IOC
ABSAA IOC (Due Regard)
MIL-HDBK-516 Update
UAS TCRG Maint. / Reliability
NASA Final Report on Airspace Integration
NASA Classification Approaches Report
NASA Final Report on Standards/Regulations
UAS Test Ranges Operational
UAS NAS Access Phases:
Accommodate
Integrate
Evolve

NASA Project Contributions

△ Milestone
☆ Critical Milestone
▲ Partially Funded or Supported by UAS in the NAS Project



UAS NAS Access Phases: Accommodate — Integrate — Evolve

Note: Acronyms can be found on the Notes Page associated with this slide.

Committee Recommendation

Short Title of the Proposed Recommendation:

UAS in the NAS Project Demonstration Mission

Short Description of the Proposed Recommendation:

The NASA UAS in the NAS Project plans as part of their Phase II a variety of flight tests to validate concepts developed as part of their research. The Committee recommends that in addition to these flight tests, one or more "capstone" demonstrations be incorporated into the program plan. These "graduation exercises" should serve to pull together and focus multiple research threads, and provide a compelling test or demonstration that the programs various stakeholders will find compelling and convincing.

Major Reasons for Proposing the Recommendation:

The Committee is concerned that sufficient impact is made as a result of the project's research. These capstone demonstrations would find their way onto the integrated master plan, and would ideally involve both NASA and outside participants, demonstrating the access barriers broken down as a result of the NASA research.

Consequences of No Action on the Proposed Recommendation:

Absent compelling capstone events, the various research elements may never achieve the desired synergy.

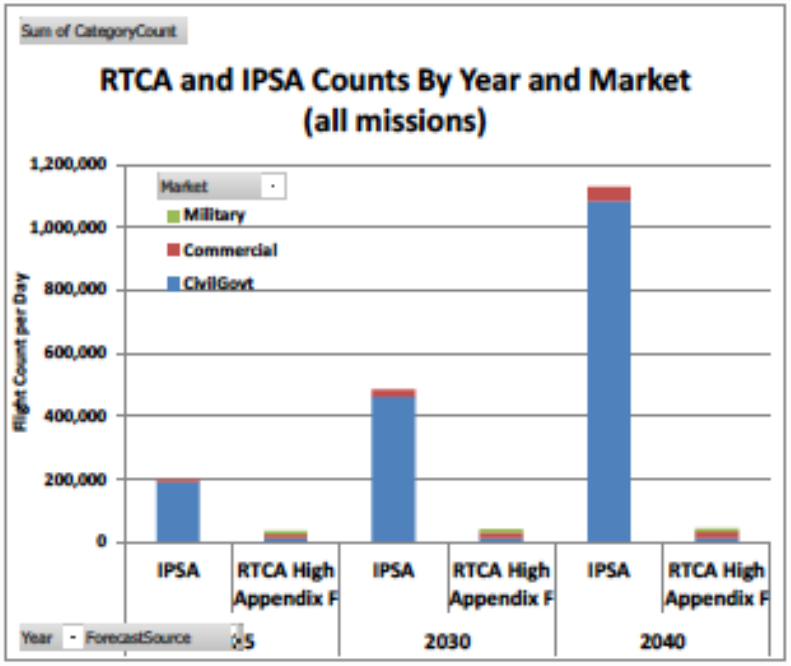
Summary of Flight Projections

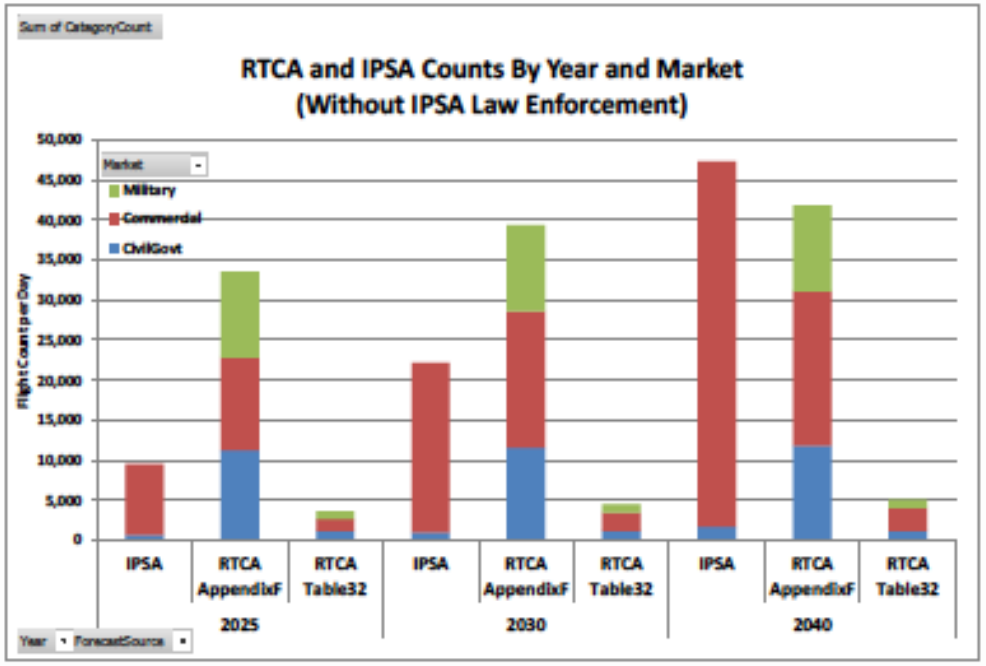
- Using industry forecasts of UAS aircraft from the Radio Technical Commission for Aeronautics (RTCA), as well as Joint Program and Development Office (JPDO) estimates, the Interagency Program and Systems Analysis (IPSA) Division produced three UAS “flight data sets”

- The forecast data provided information about UAS aircraft counts which were translated into actual flights

- IPSA UAS flight projections, although consistent with the data sources, are subject to uncertainties

Comparing Flight Counts from RTCA and IPSA





- Law enforcement / surveillance is the largest source of demand for UAS flights in the IPSA forecast
- IPSA forecast did not consider the military market, i.e. military UAS' using civilian airspace

UAS Business Case

- As part of IPSA, the UAS Business Case Analysis Team was asked to quantify the potential scale and benefits associated with the civilian and commercial markets for UAS vehicles
- Four specific business case scenarios were completed in FY12 and were selected for study to complement the work completed by the JPDO UAS Coordination Team
- ***All results should be considered preliminary, as they have not yet been veted by the larger community of UAS experts. These results will serve as a starting point for discussions around the use and future of UAS vehicles in the NAS***

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UAS Business Case Analyses – Preliminary Results

Preliminary Business Case Results

UAS Mission	Baseline Vehicle	Test Case Vehicle	$NPV
Pipeline Inspection	• Piston Fixed-Wing • Piston & Turbine Rotorcraft	• ScanEagle UAS	$43.1 Million
Law Enforcement	• Piston Fixed-Wing • Piston & Turbine Rotorcraft	• Honeywell RQ-16 T-Hawk • Aerovironment Raven	$3.5 Billion
Mid-Sized Cargo	• Cessna 208 Grand Caravan	• Unmanned Cessna 208 Grand Caravan Retrofit	$6.0 Million
Border Patrol	• Variety of Manned Piston & Turbine Aircraft	• Predator-B/Repear UAS • ScanEagle UAS	Flight hours equal to 150% of baseline*
Site Security	• Manned Security Patrols	• DraganFlyer X6 Unmanned Quadcopter	Forthcoming

** On average; a number of different scenarios were run in this analysis*

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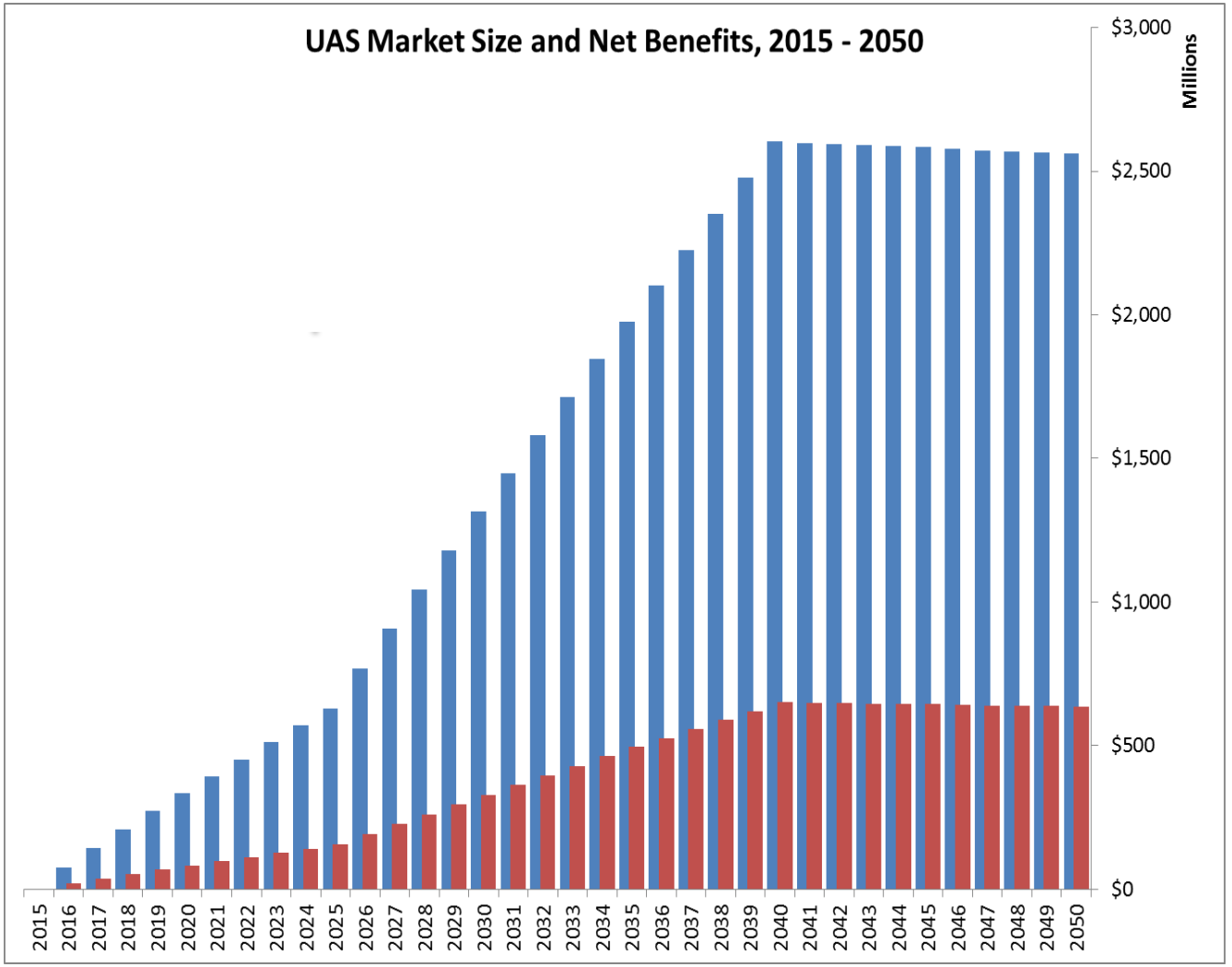
General UAS Market Model – Preliminary Results

Preliminary Market Model Results



Committee Finding

The Committee would like to commend the UAS Systems Analysis work that NASA is supporting through the Joint Program and Development Office (JPDO). The business analysis and future flight data modeling is highly necessary work and of great benefit to the community. While the analysis is preliminary, it is a good starting point and clearly illustrates UAS will have a significant impact on the NAS. The Subcommittee strongly encourages NASA and the UAS Project to continue supporting and expanding this important effort throughout Phase II. This work should also be fed back directly into Phase II planning, to focus and enlighten the planning of the next phase research elements.